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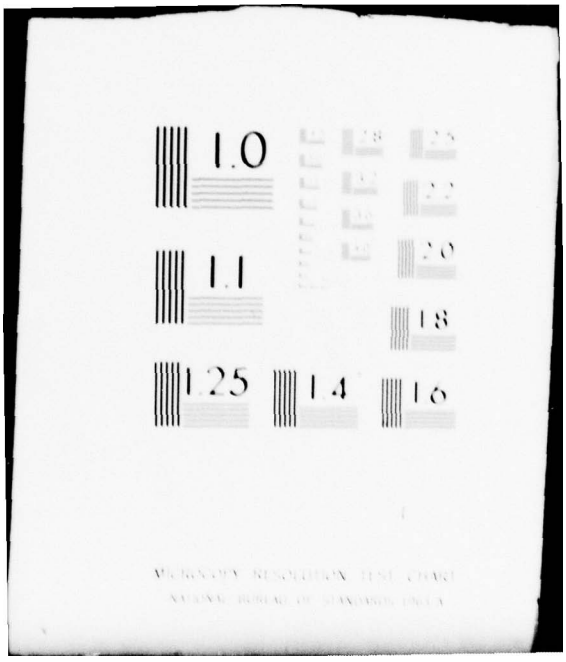
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FAMILY HOUSING UTILITY METERING PROGRAM ANNUAL REPORT PHASE I: INSTALLATION ON 3 ARMY BASES

Adam F. Renner

Interim Report

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

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Prepared by
Technology Support Division
US Army Facilities Engineering Support Agency
Fort Belvoir, Virginia 22060

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report covers the installation phase of the Army's portion of the DOD Family Housing Utility Metering Program directed by Congress. A description of the design, contracting and installation of the utility meters at Yuma Proving Ground, Fort Gordon and Fort Eustis is presented together with a brief description of the methods of handling the various tasks involved and the difficulties that arose as a result of the compressed time frame allotted this project.

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

i. Abstract

The Family Housing Utility Metering Program is a Quad-Service DOD program directed by Congress to determine the actual energy consumption in approximately 10,000 family housing units in military installations. The pilot program extends over a period of about 18 months in FY78-79 with a final report due in Congress by 1 January 1980.

The following report covers the installation phase of the Army's portion of the program and includes the description of the design, contracting and installation activities on 3 posts, namely Yuma PG, AZ; Fort Gordon, GA; and Fort Eustis, VA; together with a brief description of the methods of handling the various tasks involved with the difficulties that arose as a result of the compressed time frame allotted this project.

A report on Phase II of the Family Housing Metering Test Program covering the billing method, norm calculation, metering data collected, ADP organization etc as implemented by the Army will be published at the end of the test program in the first quarter of FY80.

ACKNOWLEDGEMENT

Although a task of the magnitude described in this report requires the dedication and concerted effort of numerous individuals, the contribution of the following persons should be acknowledged specifically without which the Army's share of the Family Housing Metering Test Program would not have had the success as it did.

Brig. Gen. Walter O. Bachus, USA-CE-DFE (RET.), for assigning Top Priority to the test program and for his motivation of personnel through his firm belief that the Army can accomplish a given task equally well, if not better, than the other services even under adverse conditions.

COL James R. C. Miller, USA-CE, former Commander and Director of FESA, for his untiring effort to bring the entire test program into one coordinated unit.

Mr. Rick Moss, Elec-Engr., FESA-ED, for his outstanding contribution in the procurement of the electric meters and the coordination of the installation phase of the program on the three Army posts.

1. Introduction

The House bill for Military Construction, 1978, (Public Law 95-82) included funds for a two year program to individually meter energy consumed in military family housing units in the United States and its possessions. Under the program, the Secretary of Defense was directed to establish reasonable energy consumption ceilings for family housing and to assess occupants for any consumption in excess of that established ceiling. The Senate conferees argued that such a program would affect the entire military pay and compensation question and before implementation on a large scale a test should be conducted to determine the feasibility of energy consumption metering on military housing units.

Funds were authorized by PL 95-101 for a pilot test program to install meters on a select number of military installations. To prepare "norms" of energy consumption, to read the meters and develop mock-billing procedures. The Department of Navy was tasked to develop the Family Housing Mock Utility Billing System (FH/MUBS) to be jointly used by the Quad-services. An Ad Hoc Committee was convened to establish norms of energy consumption making use of a computer program referred to as Building Loads and Analysis of System Thermodynamics (BLAST). The Corps of Engineers Research Laboratory (CERL) has been tasked to run the "BLAST" Program on representative housing units using field information collected on-site by FESA.

The following specific DOD guidelines were included in the test program:

a. The cost of the meter installation for the test should be limited to $8.5 million.

b. A representative cross section of at least 10,000 housing units from all regions of the country, including those with meters at the present time, should be included in the test equally distributed among the Quad-service.

c. A part of the test sample should include the metering of housing units in which storm windows, thicker insulation and other energy saving devices have been installed in order to test the comparative effectiveness of the services' ongoing energy conservation programs.

d. Occupants should receive "bills" for the excess energy consumed but would <u>not</u> be required to pay for the excess energy consumed during the test period.

e. The test should be conducted on the following schedule with progress reports submitted to the Secretary of Defense at each milestone:

1. A complete test design by 1 October 1977.

2. A complete energy retrofit and meter installation on test units by 1 January 1978.

3. A Progress Report by 1 July 1978.

4. A Progress Report with preliminary findings by 1 January 1979.

5. The Final Report by 1 January 1980.

The conferees also agreed that all new family housing authorized in this and future military construction authorization bills should be provided with energy consumption metering devices.

In compliance with the above agreements and schedules a Joint Services - OSD task force meeting was held on 18 August 1977 in which the installations shown in Table 1-1 have been selected as best meeting the requirements of the test program.

Table 1-1: Quad-Service Distribution of Family Housing Units for Metering Test Program

Climatic Area	Installation	Housing Units		Service
		Original Plan	Present Count	
Cold	PWC Great Lakes, IL	2,089	2,089	Navy
Hot & Humid	Ft. Gordon, GA	873	879	Army
	MCAS Beaufort, SC	1,276	1,276	Marine Corps
	Keesler AFB, MS	1,982	1,535	Air Force
Hot & Dry	Cannon AFB, NM	1,012	1,012	Air Force
	Yuma Prvg. Grnd., AZ	290	290	Army
Moderate w/Air Cond.	MCDEC Quantico, VA	1,820	1,110	Marine Corps
	Ft. Eustis, VA	1,325	1,325	Army
Moderate wo/Air Cond.	Point Magu, CA	883	883	Navy
	NCBC Hueneme, CA	500	215	Navy
TOTALS:	Ten Installations	12,050	10,614	

As discussed in the task force meeting, the installations selected should determine the best and most expeditious methods for installing the required meters through local utility companies, by contract or by in-house personnel. Furthermore, the Navy was charged with the task to develop procedures for meter reading and data processing for purposes of "mock billing" of occupants for the energy consumed during the test period.

In a subsequent meeting on 15 September 1977 the Air Force requested and obtained approval to delete the housing units of Keesler AFB and to substitute Little Rock, Arkansas, instead. The reason for the switch was that Little Rock AFB, has heat pumps installed which was of interest to the test program from the standpoint of energy consumption of this type of heating and cooling system. Additional changes in the total number of units were made as the utility metering program progressed for various reasons so that the final distribution of housing units among the four services is as shown in Table 1-2.

Table 1-2. Final Distribution of Family Housing Units for Metering Test Program

Army	2,129 units on 3 bases
Navy	3,187 units on 3 bases
Air Force	2,547 units on 2 bases
Marines	2,386 units on 2 bases

Similarly the original target dates proved to be impractical and after compromising the original schedule the time table shown in Table 1-3 was approved by the OSD.

Table 1-3. Major Milestones of Family Housing Metering Test Program

Completion of the meter installation:	30 June 1978
Completion of the ADP Program for Customer Billing:	30 September 1978
Run of Test Program:	1 October 1978 through 30 September 1979
Final Report to Congress:	1 January 1980

In the following sections the installation portion of the Army's utility metering program will be described from the viewpoint of installation problems, design, procurement and costs with the "lessons learned" summarized in the conclusion.

2. The Army's Assignment

The Army's portion of the family housing metering program consists of three posts, namely Yuma Proving Ground, Arizona, Fort Gordon, Georgia; and Fort Eustis, Virginia. Each of the posts represents a different climatic area as well as a different mix of energy sources. Yuma PG with its hot climate and low humidity desert environment represents a consumer with primarily air conditioning requirements. The quarters have electric utility only. Refrigeration type cooling and resistance type heating is used. Fort Gordon uses electricity and gas while Fort Eustis uses electricity and oil for residential requirements.

The housing distribution for this program on each Army base is shown in Table 2-1, 2-2 and 2-3.

Table 2-1. Family Housing Units in Test Program at Yuma Proving Ground

Subdivision	Housing Style	No. of Houses	No. of Units	No. of Units Metered		
				Electric	Gas	Oil
Officers' Housing Area(800/900 Block)	Single	45	45	45	-	-
	Duplex	18	36	36	-	-
Enlisted Men's Housing Area						
1400 Block	Single	65	65	65	-	-
1300 Block	Duplex	72	144	144	-	-
Total:		200	290	290	-	-

Table 2-2. Family Housing Units in Test Program at Fort Gordon

Subdivision	Housing Style	No. of Houses	No. of Units	No. of Units Metered		
				Electric	Gas	Oil
Bordman Lake Area (Generals' Quarters)	Single	6	6	6**	1*	5**
Maglin Terrace (Officers' Quarters)	Single	27	27	27	27	-
Gordon Terrace (Enlisted Mens' Quarters)	Duplex	97	194	194	194	-
	4-Family	60	240	240	204	-
	6-Family	27	162	162	108	-
Olive Terrace (Enlisted Mens' Quarters)	Duplex	61	122	122	8	-
McNair Terrace (Enlisted Mens' Quarters)	Duplex (New)	39	78	78	4	-
	Single (Old)	2	2	2	2	-
	Duplex (Old)	11	22	22	20	-
	4-Family	3	12	12	12	-
	6-Family	1	6	6	6	-
	8-Family	1	8	8	8	-
Total:		334	879	879	599	5

*Propane Gas (Not Metered)

**Meters installed previously in FY78 by in-house personnel.

Table 2-3. Family Housing Units in Test Program at Fort Eustis

Subdivision	Housing Style	No. of Houses	No. of Units	No. of Units Metered	
				Electric	Oil
100 Area	Single	5	5	2	1
	Duplex	2	4	2	0
	4-Family	7	28	16	0
	5-Family	6	30	10	10
	6-Family	5	30	18	0
	7-Family	11	77	42	14
	8-Family	14	112	40	16
	14-Family	6	84	84	70
	Subtotal/Area	56	370	214	111
300 Area	4-Family	8	32	32	32
	6-Family	3	18	18	18
	7-Family	4	28	28	28
	8-Family	17	136	136	136
	Subtotal/Area	32	214	214	214
400 Area	Single	2	2	2	2
	Subtotal/Area	2	2	2	2
1100 Area	Single	3	3	3	3
	4-Family	7	28	28	28
	6-Family	2	12	12	12
	7-Family	3	21	21	21
	8-Family	5	40	40	40
	Subtotal/Area	20	104	104	104

Table 2-3. (Continued)

Subdivision	Housing Style	No. of Houses	No. of Units	No. of Units Metered	
				Electric	Oil
1900 Area	Duplex	30	60	60	60
	Subtotal/Area	30	60	60	60
2100 Area	Duplex	17	34	34	34
	Subtotal/Area	17	34	34	34
2300 Area	4-Family	48	192	192	192
	6-Family	13	78	78	78
	7-Family	2	14	14	14
	8-Family	13	104	104	104
	Subtotal/Area	76	388	388	388
2500 Area	4-Family	7	28	28	28
	6-Family	4	24	24	24
	7-Family	1	7	7	7
	8-Family	5	40	40	40
	Subtotal/Area	17	99	99	99
2700 Area	Single	23	23	23	23
	Subtotal/Area	23	23	23	23
2900 Area	Single	9	9	9	9
	Duplex	11	22	22	22
	Subtotal/Area	20	31	31	31
	Total/Ft. Eustis	293	1,325	1,169	1,066

As the metering installation planning progressed, complications arose in some housing units because of variations in building styles and existing utility service layouts. For example, in the new housing areas at Fort Gordon the T-splices of the gas line serving two family units were found to be imbedded in the walls and could not be accessed without tearing the plasterboard open which, in turn, would have required to move the family into temporary quarters for the time duration of the gas meter installation, (estimated at that time 2-3 days per duplex). Since, however, 200 families would have been affected by this disruption it was not feasible to provide temporary housing for a population of this magnitude. Rather it was considered more advantageous to take representative samples of these housing units and install the remainder of the meters at a time when the unit is not occupied.

At Fort Eustis 370 homes were under a renovation contract consequently no alteration of any sort could be made on these units until released by the renovation contractor who has until September 1979 to complete this job. While 214 units were released by 1 October 1978 it is questionable just how many of the remaining 156 units will be available for the test program.

3. The Design Phase

While Yuma PG and Fort Eustis accomplished the meter installation design in-house or by contract, Fort Gordon approached FESA for assistance. In all three cases the drawings prepared showed modifications to the existing utilities to accommodate the meters. In order to accomplish uniformity, however, FESA developed a set of specifications for the meters which was distributed to the Facilities Engineers for consideration in the design and procurement. (See Appendix "A")

Yuma PG accomplished the design with military personnel (one 1LT designer and one SP4 draftsman). The details are shown on YPG-FE Dwg/File No 3295-77, dtd Sep 77. The family housing units use electric energy only and the service consists of 220-volt, 3 phase, 4 wire connections. The installation of meters could be accomplished by disconnecting the existing wires at the switch panel and then inserting the electric meter between the main breaker and the service entrance with only few variations. The approximate time span of the design phase was 2 man-months with no other labor charges but salaries for military personnel. Similarly the contract specifications for electrical installation were drafted by in-house personnel and were reviewd by FESA.

Fort Gordon received the assistance of FESA to design the metering installation for their housing units and also to draft the necessary service specifications for the installation contract. An on-site survey was conducted by the electrical

and mechanical designers from FESA in November 1977 in order to define the various building styles, electric service entrance variations and gas piping layouts. Typical design sketches were prepared for all units having similar utility layouts. In order to keep the number of drawings at a minimum, each housing unit was grouped in its respective subdivision with other houses of similar layout and tabulated in a listing of housing numbers giving reference to the applicable electrical and gas meter installation. The drafting portion of the design was then contracted to Vector Engineering in Springfield, NJ, for a cost of $15,054. The final product included:

7 - Listings of units by house numbers and installation references;
3 - Gas meter installation drawings;
4 - Electric meter installation drawings.

The preparation of the contract package including field survey and sketches required 2 man-months of engineering effort provided by FESA.

Fort Eustis contracted the design effort to a local A/E firm, Spiers & Waltz Co. in Newport News, VA. The contractor produced 19 drawings for the electric meter and oil furnace run time meter installation and hook up. The cost of this effort is broken down as follows:

(a) 10 drawings for 955 housing units $17,562;

(b) 9 drawings for 370 housing units $ 7,656.

The 370 units, located in the Wherry subdivision, required special consideration. Since these were the units included in a renovation contract executed concurrently with the meter installation care had to be exercised that the drawings reflected the changes of the renovation on the building exterior.

4. Procurement

In the procurement cycle two distinct segments can be identified:

(a) the procurement of the meters;

(b) the procurement of contractor services for the installation of the meters.

Both aspects will be described together with the difficulties that arose in the process of negotiations. It should be emphasized, however, that the overall family housing metering program placed unusual demands on the contract negotiations in order to complete the test by 1 October 1979. Looking at the time frame (Table 2-4) this becomes obvious when the individual target dates are compared with the magnitude of the tasks involved.

Table 2-4. Target Dates for Design & Procurement of Family Housing Metering Installation

Program Element	Allotted Time Calendar Months	Target Date	Actual Date
Preliminary Design & Field Survey	2	31 Oct 77	30 Nov 77
Design of Metering Installation	2	31 Dec 77	31 Jan 78
Preparation of Contract Package	2	31 Mar 78	31 Mar 78
Advertising & Negotiation of Contract	1	30 Apr 78	30 Apr 78
Execution of Contract & Completion of Installation	2	30 Jun 78	31 Aug 78

The urgency to negotiate a contract within the shortest possible time was dictated by the revised target date of 30 June 1978 to complete the installation phase of the program irrespective of the number of housing units involved. Any delay in the contract negotiation would have penalized the installation time required by the contractor to complete his job. In this sense the contract negotiations were conducted under "emergency conditions" and should not be considered as representative of normal contracting procedures.

On an individual basis the following factual data apply to the 3 Army posts.

Yuma Proving Ground: Because of the small number of housing units involved, the installation design was completed in October 1977. Consequently contract negotiations could be conducted the following month with a completion in December 1977. The order for the electric meters was placed by the contractor immediately after the award of the contract. Since, however, a 3-phase service is not a conventional residential utility service, a 6-8 week delivery was allowed in agreement with the schedule and performance plan.

The contract was let for the installation of 290 electric meters for a contract price of $101,128. The award went to Line Power Inc., Pensacola, Florida.

Fort Gordon prepared the contract package in February 1978 and advertised the contract the following month. The contractors were asked to bid on the

basis of two completion dates, namely 30 Jun 78 and 31 Aug 78 respectively. A total of four bids were received ranging in price from $218,128 to $425,445. The low bidder justified his estimate in writing but could not confirm the contract schedule and performance requirements. One bidder protested in writing in objection to the performance schedule. The protest was based on the performance of similar work for the Marine Corps. The other bidders stated at the bid opening meeting that the 30 Jun 78 completion date could not be met because of the long lead time required for the procurement of the meters.

All four bids were then rejected by the Contracting Office for the simple reason that in the contract alternate completion dates could not be justified. The alternative was to readvertise the contract for a completion date of 31 Aug 78. In order to eliminate the long lead time for meter procurement, FESA agreed to purchase the electric meters by negotiating special considerations with local distributors. The meters were then delivered to Fort Gordon and furnished to the Contractor as Government Furnished Equipment (GFE).

The gas meter and the electric meter installation contracts were negotiated separately. The gas meter contract was awarded to Hancock Plumbing and Heating Company of Macon, Georgia, for a consideration of $134,227. The contractor was responsible for the procurement and installation of 593 gas meters. The electrical installation was awarded to Guy C. Smith Construction Company of Augusta, Georgia, for a price of $140,070 for the installation of 873 meters with the stipulation that the Government will furnish the meters. The price of the kWh-meters was $58,977 under a separate procurement.

Fort Eustis also had two contract actions, necessitated by the fact that 370 of the 1,325 housing units were under renovation and required special considerations in the contract draft. The Wherry Subdivision housing units were contracted to Mallory Electric Company for the installation of 370 electric meters and 262 oil burner run time meters at a cost of $92,067. The other contract was let to North Landing Line Construction Company of Virginia Beach, VA, for the installation of 955 electric meters and an equal number of oil burner run time meters at a cost of $567,118. In both cases the contractor furnished the oil burner run time meter whereas the electric meters were procured by FESA and delivered to the Contractor on the job site as GFE. The completion date for the installation was specified as 31 Aug 78 in both cases.

5. Installation

In general, no major problems were experienced on all 3 posts in the installation phase of the family housing metering program once the meters were delivered by the vendors. In particular, the electric kilowatt-hour

meters were difficult to obtain with a delivery schedule suitable to the time frame of this program since these meters are not stocked in quantities by the distributors because of the limited demand outside of utility companies.

The performance of the individual contractors is shown on the curves of Figures 5-1 through 5-4. Accordingly, the installation of 290 electric meters at Yuma PG required approximately 41 working days corresponding to an installation rate of 7 meters per day. Work was delayed twice in the course of the contract because of delays in the delivery of the meters by the vendor.

At Fort Gordon the electric meters were delivered by the vendor on an "emergency" basis. For this reason Figure 5-2 shows no delays because of delivery schedules. The contractor proceeded at a rate of approximately 21 meters per day for 7½ weeks. The reason for the slow down during the last three weeks was that the contractor scheduled the more difficult installations for the last. Similarly the gas meter installation curve in Figure 5-3 shows an accelerated pace for the first 5 weeks of approximately 18 meters per day slowing down to 15 meters per day which represented the more difficult cases again.

One problem that remained at Fort Gordon was the gas meter installation in the new section of McNair Terrace and Olive Terrace respectively. These duplex homes are of 1972-74 vintage and have a single gas supply for the two units. The gas lines have the branch "Tee" inside the wall which required the breaking of wall and ceiling in order to expose the pipes for modification to accommodate the meters. The dislocation of families for a period of 2-3 days while the contractor made the modification to the gas supply was considered impractical considering the cost involved to place the families in temporary housing or motels and the hardship this temporary relocation would have had on the families. The problem was negotiated with the Assistant Secretary of Defense and an agreement was reached with the DOD to select a representative sample in each subdivision for metering at the discretion of the Facilities Engineer. The samples selected are tabulated in Table 5-1.

Table 5-1. Selection of Representative Samples for Gas Meter Installation at Fort Gordon

Gordon Terrace	18 - 6 Family Houses	or	108 units
Olive Terrace	8 - Duplex Houses	or	16 units
McNair Terrace	4 - Duplex Houses	or	8 units

This reduction in metering represents a loss of 280 housing units to the program (See Table 2-2).

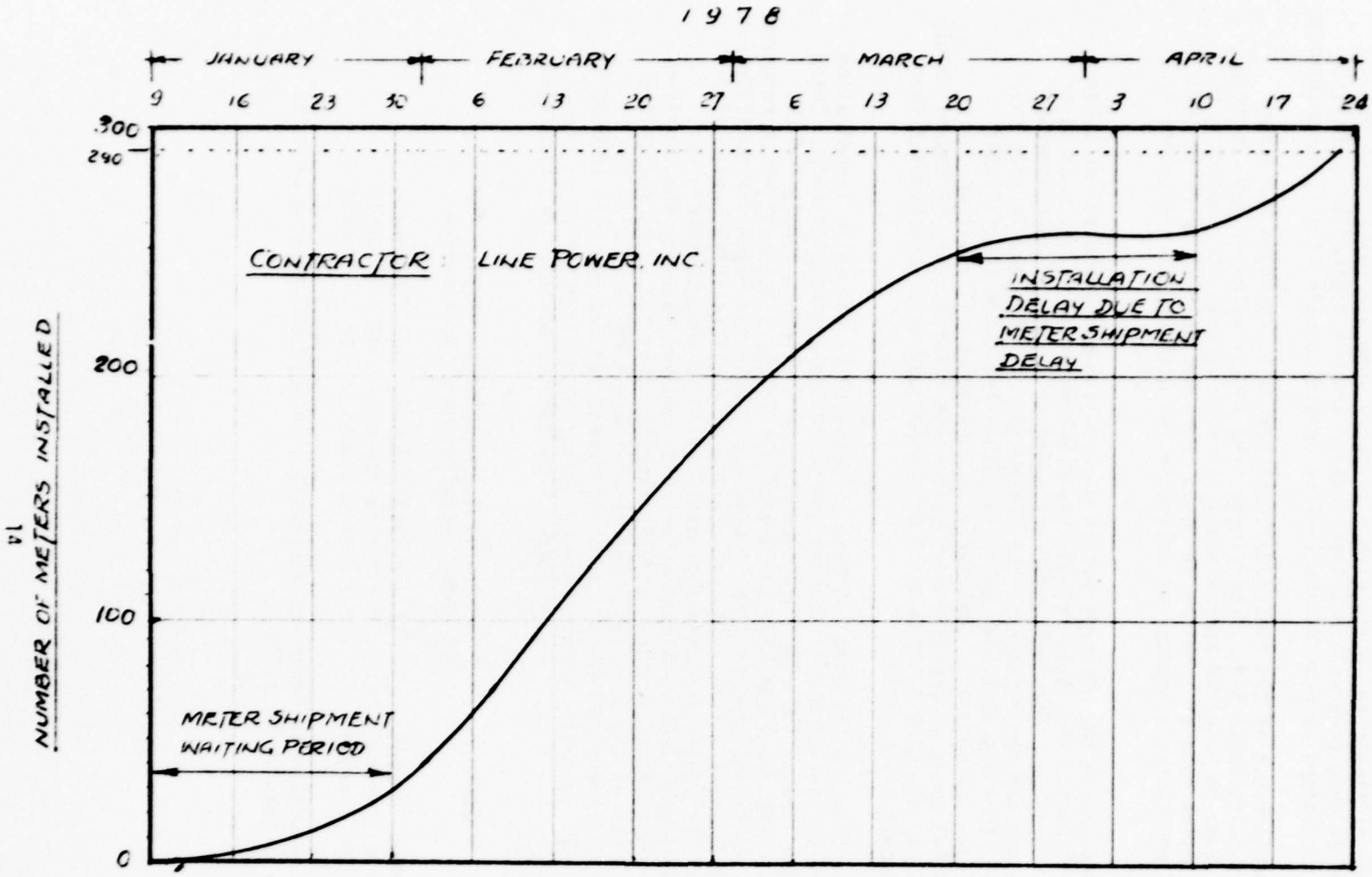

FIGURE 5-1: ELECTRIC METER INSTALLATION

YUMA PROVING GROUND, ARIZONA
FAMILY HOUSING METERING

TOTAL NUMBER INSTALLED 290

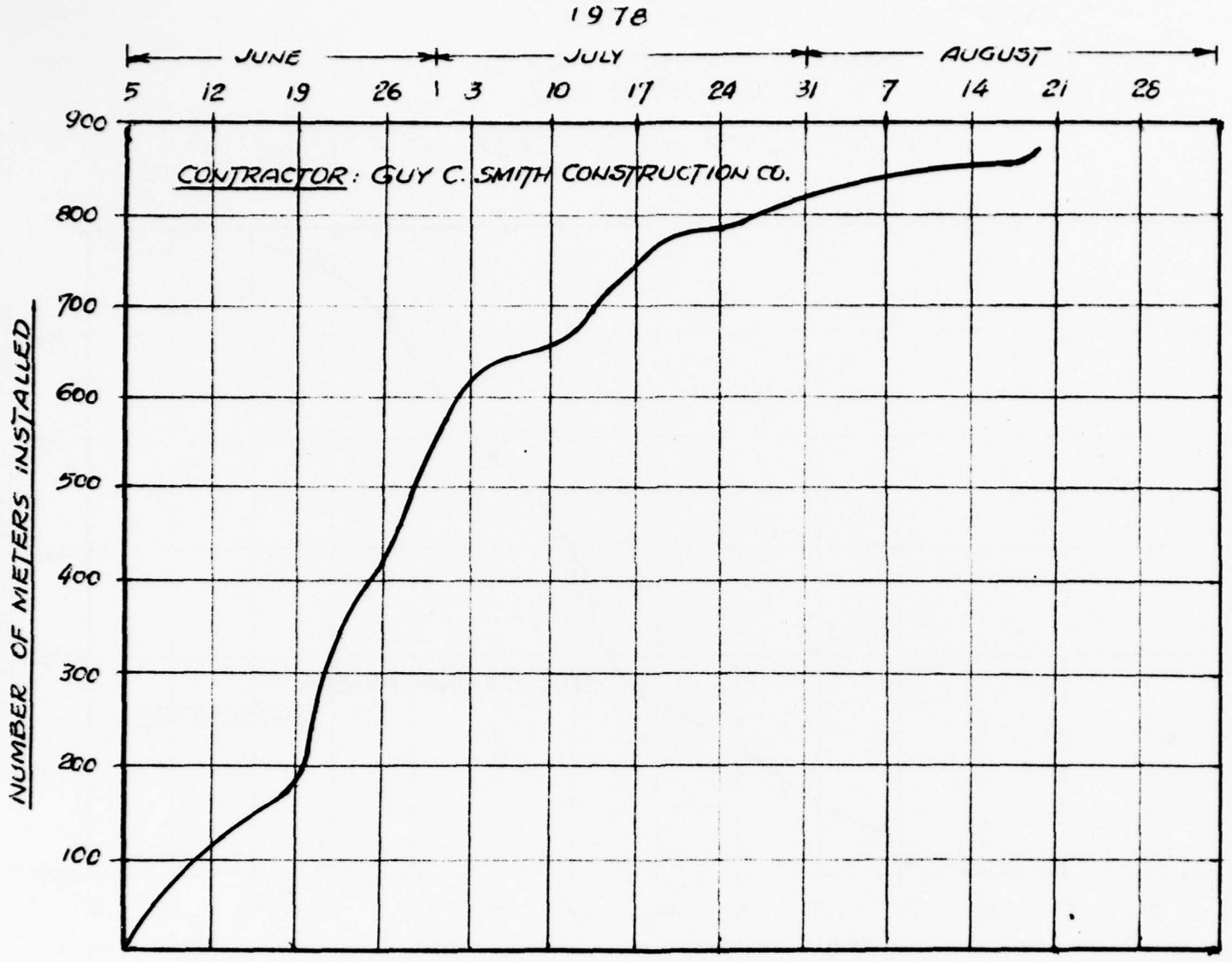

FIGURE 5-2: ELECTRIC METER INSTALLATION

FORT GORDON, GEORGIA — FAMILY HOUSING METERING

TOTAL NUMBER INSTALLED: 873

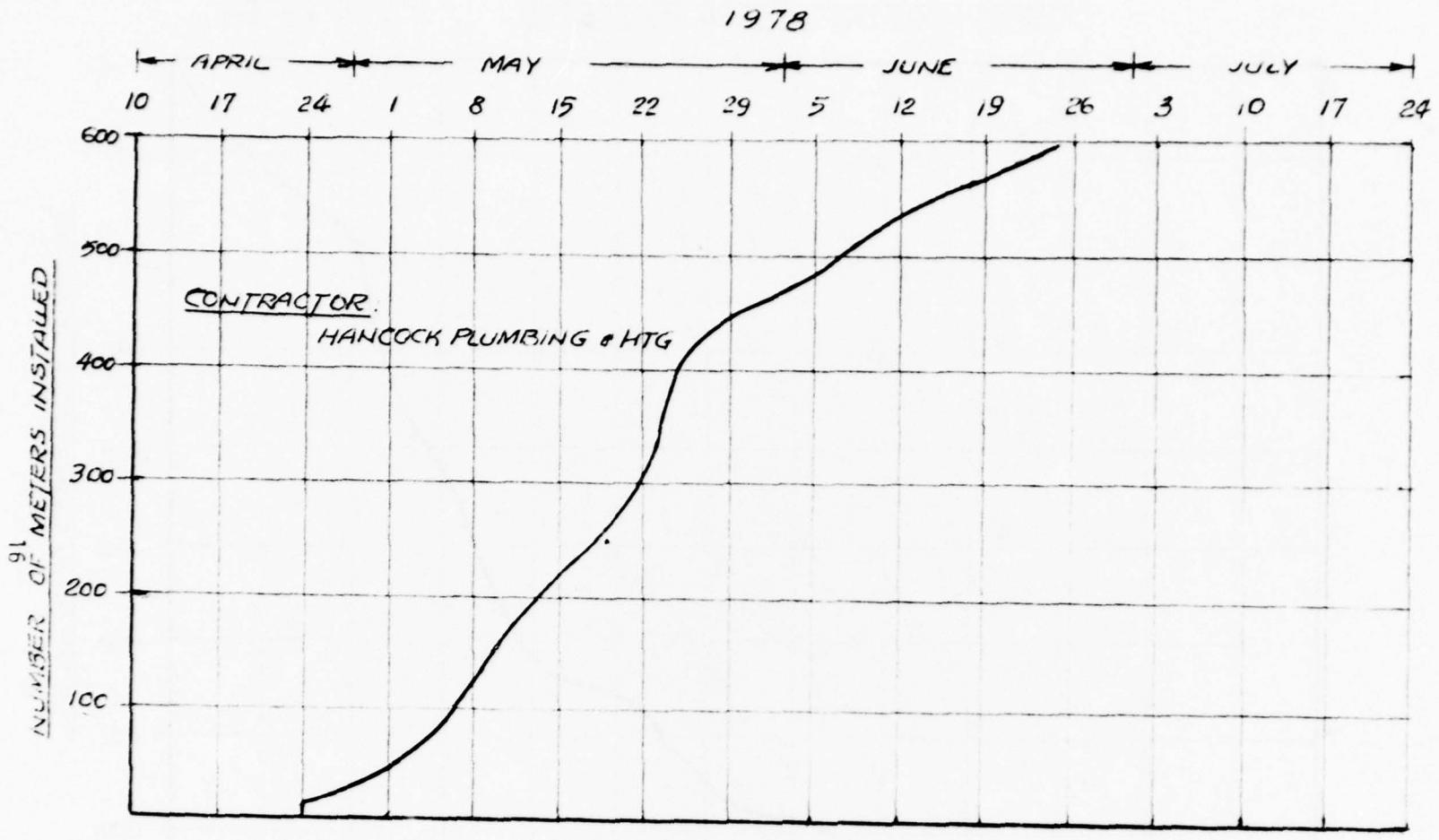

FIGURE 5-3: GAS METER INSTALLATION

FORT GORDON, GEORGIA
FAMILY HOUSING METERING

TOTAL NUMBER INSTALLED: 593

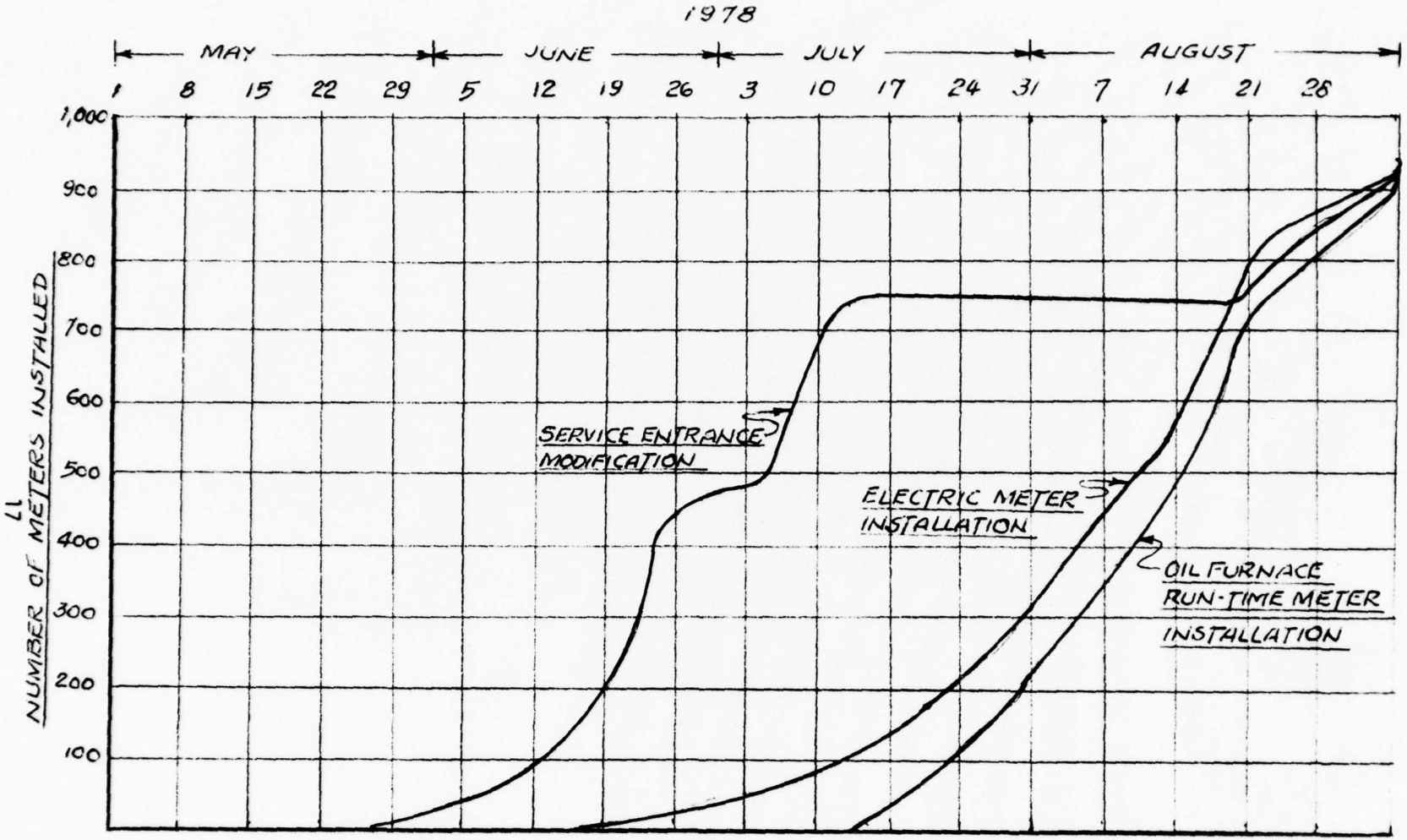

FIGURE 5-4. ELECTRIC & OIL FURNACE RUN-TIME METER INSTALLATION

FORT EUSTIS, VIRGINIA FAMILY HOUSING METERING

TOTAL NUMBER INSTALLED: 955 ELECTRIC METERS
955 RUN-TIME METERS

Since the FE at Fort Gordon did not have "as built" drawings of the gas piping layout the contractor had to determine the pipe run inside the buildings by opening the walls. It was fortunate, however, that the piping was the same in identical style buildings so that after the initial cut-and-try procedure the contractor was able to run the new piping with a minimum of damage to the walls and ceiling. The inconvenience to the individual families was also minimized so that no relocations took place during the contract period.

Fort Eustis had a problem of a different nature. As mentioned previously in the Wherry Subdivision (100 Area) the housing units were undergoing remodeling under a different contract consequently no alteration to the building could be made prior to the release of the units by the contractor and acceptance by the Government. For this reason the utility meters (kilowatt-hour and oil furnace run-time) were installed as the buildings became available. Since the remodeling contract extends to the end of FY79 it is questionable, at this point, just how many of the 156 housing units not metered at present will become available for the test program. In Table 2-3 the status on 15 December 1978 is reported.

The cost and performance rate of the meter installation activity is summarized in Table 5-2. It should be noted that the Yuma PG and Fort Eustis electric installation contract includes the service entrance modification work required to accommodate the new meters whereas at Fort Gordon the electric work primarily involved the replacement of existing breaker boxes with preassembled meter sockets and disconnect switches. The gas meter and oil furnace run-time meters are apparently compatible from a unit installation cost standpoint although the skills required to install them are entirely different and the time required per run-time meter is half of the installation time of the gas meter. The cost figures given for the 370 units in the Wherry Subdivision at Fort Eustis are inconclusive since not all data of the installation are available at this time.

Table 5-2. Summary of Installation Expenditures and Time

ARMY POST	TYPE METER INSTALLED	CONTRACT $	NUMBER INSTALLED	APPROX. COST PER UNIT	INST. TIME DAYS	INST. RATE PER DAY
Yuma PG	Electric	$101,128	290	$349.00	45	6.5
Ft. Gordon	Electric	$140,070	873	$160.00	52	17
	Gas	$134,227	593	$226.00	45	13
Ft. Eustis	Electirc	$567,118	955	$354.00**	50	19
	& Oil		955	$240.00**	35	27
	Electric	$ 92,067	370	*	*	*
	& Oil		262	*	*	*

* Project Incomplete
** Estimated Cost based on Contract $

6. Special Equipment Requirements

The Family Housing Mock Utility Billing System (FH/MUBS) requires input data from each installation concerning prevalent daily temperatures of the ambient environment. For this purpose FESA recommended that each installation acquire/purchase a recorder that monitors the outdoor air temperature on a 24-hour basis. The energy consumption norms (developed on the basis of historical weather information and the data from the family housing survey at each post) are adjusted daily to conform to the actual energy demand of the housing units under the existing weather conditions. The temperature variation within a 24-hour period is recorded on a chart from which the input data to the FH/MUBS are taken manually by the meter reader. In addition, the meter reader also determines daily the water supply temperature with an ordinary thermometer since only one reading per day is required. The specifications for the recorders recommended by FESA are shown on the Manufacturers' Catalog Sheet in Appendix "B".

It should be noted, however, that the above instruments are for the convenience of the FH/MUBS administrator and other methods can be used by the installations if so desired. For example, Fort Eustis did not procure a temperature recorder but instead, employed the services of the local weather bureau operating on post to obtain the required temperature data. Similarly Yuma Proving Ground obtains the temperature information from the local weather bureau. The disadvantage of this method is the loss of a permanent daily chart record which makes the checking of the information at a later date more difficult.

7. Conclusion

Looking at the meter installation in retrospect it can be said, in general, that most of the difficulties arose from the compression of the metering program schedule which allocated less than 60 days to the contractor for the actual installation of the meters. Since the contractor had to purchase the meters, the quoted delivery time (for quantities of meters) ranged from 3-8 weeks from which the contractor's dilemma is obvious. Special negotiations conducted by FESA with manufacturers to expedite deliveries to meet the installation schedules of the Army should be considered as an exceptional condition. Under normal circumstances the procurement of the meters should present no special problems to the contractor and the installation should proceed without penalty to the contract if sufficient time is allowed for meter procurement and delivery, normally 8-12 weeks.

The installation difficulties with the gas meters on housing units with gas lines imbedded in walls and ceilings is a more serious problem if it were extended on a larger scale. Although family dislocations could be avoided at Fort Gordon (because of the relatively small number of units involved), in general, temporary family placements should be calculated into the cost of future gas meter installations.

The utility meter installation was also impeded by the lack of adequate documentation of existing utility system layouts in the Facility Engineer's Office. The essential information required for the design of the metering layout was either not available at all (e.g., the gas piping inside the family housing units at Fort Gordon) or the information did not reflect the changes made on the system since its installation. For this reason an extensive survey must be conducted on site prior to the initiation of the design in order to insure that the latest "as built" information is used.

When scheduling the installation of the meters it should be kept in mind that the weather conditions of the season will affect the performance of the contractor. To a certain extent this can be seen from the data of Table 5-2. The installation at Yuma Proving Ground took place in the winter months and proceeded at a much slower pace than at Fort Gordon and at Fort Eustis which was accomplished in the Spring and Summer months. Also from the standpoint of inconvenience to the individual families the warmer months of the year are preferable to the months in which extensive heating is required for personal comfort.

A very important feature of the meter installation (which is often ignored) is the adherence to rigorous inspection procedures. To retrofit a job is time consuming and costly and can be avoided with proper inspection in the course of installation. In fact, many problems that arose at Fort Gordon and at Fort Eustis at the end of the contract can be attributed directly to a lack of inspection. For example, all the oil furnace run time meters at Fort Eustis had to be checked and most of them rewired at the end of the installation. Typical contractor erros found were:

(a) Meter had loose or open connections.

(b) Meter wired to the AC Supply circuit and ran continuously.

(c) Meter wired into the fan blower control circuit.

Similarly at Fort Gordon the contractor selected couplings not suitable for connecting the gas meters to the supply line which necessitated the subsequent removal of these couplings from the system after the expiration of the contract. Rigorous inspection procedures during the contract performance would have eliminated these and similar problems.

Since the meters are used for measuring energy consumption of individual households for purposes of billing it should be pointed out that the calibration of the instruments are very important from a technical as well as from a legal standpoint. Normally the meters are calibrated at the factory before shipment. There is no guarantee, however, that the calibration will be the same when the shipment arrives at the destination and normally the meters will have to be recalibrated before installation by the contractor. Because of the compressed time frame of the Family Housing Metering Test Program this was not done at any of the 3 Army installations. Since only fictitious charges are levied against customers during the test no legal basis will exist for refunds resulting from metering inaccuracies. In an actual situation in the future, however, the calibration of the meters before installation and periodically (at least every 5 years) cannot be ignored.

Another point of concern is the method used at Fort Eustis to measure oil consumption by individual households during the heating season. Since oil flow meters for small consumption are expensive (approx. $600 ea) an alternate method of metering was employed determining the cycle time of the oil burner with a timer. Knowing the gallons/hour output of the nozzle the total consumption can be calculated by multiplying the output by the number of hours the burner (furnace) was on during the billing period. Inaccuracies in this method enter through manufacturing variations of the nozzles, material deterioration with aging and impurity depositions from the oil flow. For this reason it is recommended that the burner/timer system be calibrated with an actual oil flow meter at the time of installation and then recalibrated at 3 to 5 years interval to insure that no customer is overcharged because of inaccuracies in the computation of oil consumption.

APPENDIX "A"

DA FAMILY HOUSING UTILITY METERING TEST
STANDARD FEATURES OF ELECTRIC AND NATURAL GAS METERS

All electric meters (watthour meters) utilized in the DA Family Housing Metering Test shall feature all of the following:

1. SELF-CONTAINED CONSTRUCTION: A self-contained meter is a meter which does not require the installation of instrument transformers and is installed directly in the service entrance cable (cable from service drop to main disconnect(s)). This will provide for substantial savings in installation costs and will eliminate instrument transformer errors, however slight. (Instrument transformers specifically include potential and current transformers.)

2. SOCKET-CONNECTED: This type of meter is installed by plugging it into a permanently installed socket. The use of socket connected meters will provide ease in removing and installing meters when required for testing, maintenance, calibration, replacement, etc.

3. AUTOMATIC CIRCUIT-CLOSING SOCKET: Most socket-connected meters in utility use today will disconnect service to the customer when it is removed from the socket. An automatic circuit closing socket automatically closes the circuit opened by removing the meter to prevent disruption of service to the customer.

Utility companies do not use this type of socket since the meter itself is used as a connect-disconnect means.

4. CLOCK-DIAL INDEX: This is the type of index currently in use by most electric utilities. Its advantages over the direct-reading digital index include:

1) Lower cost due to its simpler construction

2) Less frequent failure

3) Ease of reading at a distance away

All natural gas meters utilized in the DA Family Housing Utility Metering Test shall feature all of the following:

1. SINGLE-JOINT CONSTRUCTION: This is a type of construction in widespread use for domestic (residential) metering applications. This merely means that the meter has only one sealed joint (two case sections) which must be opened to disassemble the meter for servicing. This will provide for ease of maintenance and will make the meter more leakproof.

2. DIAPHRAGM OPERATION (POSITIVE DISPLACEMENT): Practically all meters manufactured for domestic applications are of this type. The operation of the meter consists of alternately filling and emptying two chambers enclosed by flexible diaphragms and advancing the index each time a bag is filled. This provides for low cost and accuracy at low flow rates.

3. ALL ALUMINUM CASE: This is the only available case from most or all manufacturers except in areas of alkaline soil conditions (California). This case provides for light weight (1/3 of older models) and resistance to normal corrosion caused by soil conditions (except alkaline).

4. CLOCK-DIAL INDEX: This is the standard index now in use by most utilities. This will provide the same advantages as in the case of electric meters.

5. NPT CONNECTIONS: The meters should be supplied with connections already usable with standard pipe (NPT) thread without requiring additional adaptors.

6. TEMPERATURE COMPENSATION: The meters should be supplied with temperature compensation to eliminate metering errors caused by temperature variations. This becomes most imperative when meters are exposed to outdoor temperatures. Temperature compensation is not provided on utility-owned meters since Government regulators have not required them to do so. Temperature compensation is not required since colder temperatures during heaviest gas comsumption result in errors in favor of the customer.

Weather Data for Family Housing Metering Test

In conjunction with the family housing metering test, weather data will be collected by each installation and forwarded along with the meter reading data. Forms for this purpose are being developed by the Navy and will be furnished to each installation along with the meter reading cards.

The energy consumption norms, (developed using historical weather information and the results of a family housing survey conducted at the installation) will be adjusted on the basis of this weather data, to depict the actual energy demand of the structure under the existing weather conditions. To achieve this purpose, the daily water supply temperature, the daily high and low outside air temperature, and the number of hours per day that the outside air exceeds 78°F must be measured and reported. Recommended instrumentation and/or procedures for obtaining these measurements are as follows:

a. Outside Air Temperature (in °F). A temperature recorder such as the Esterline Angus Minigraph or Weather Measure Model T621 temperature indicator with an appropriate recording device (see attached technical data) can be used to provide a continuous record of ambient air temperature and the specific data required (i.e., high and low temperatures and hours per day above 78°F) can be manually extracted from the chart record.

b. Water Supply Temperature (in °F). The water supply temperature can be measured by drawing a water sample from a convenient tap and inserting a thermometer. When following this procedure, care should be taken to obtain a sample of the water entering the building and not a sample that has been heated as a result of storage within the building piping.

ESTERLINE ANGUS
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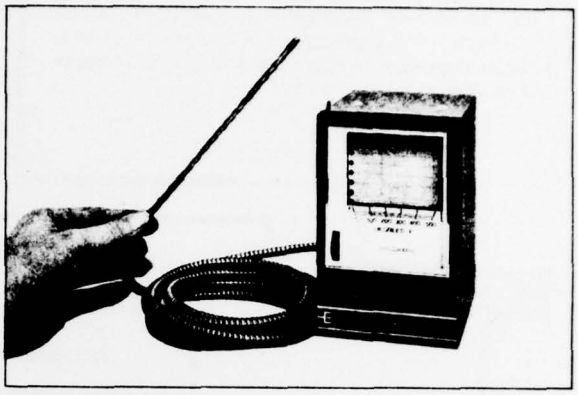
Esterline Angus Minigraph temperature recorders



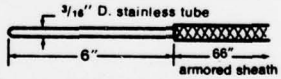
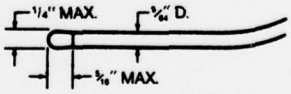
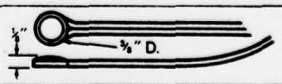
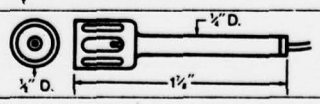
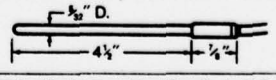
The Minigraph temperature recorder is a portable 5 lb. (2.3 kg.) giant of unsurpassed durability, versatility, and accuracy for lab or industrial use. Priced as low as $158, it measures just 3⅝" W x 5⅝" H x 4⅜" D with thermocouple ranges, 6" D with thermistor (9.2 cm W x 14.3 cm H x 11.1 cm D; 15.2 cm D with thermistor). Minigraphs record temperature in the ranges of 0-500°F to 0-300°C to 0-1000°C with a thermocouple probe. Thermistor probes, interchangeable within range limits shown below, permit temperature records from −20 to +300°F (150°C).

Inkless recording

The Temperature Minigraph uses a special stylus positioned by an impact plate against pressure sensitive paper. The inkless stylus writes a record of dots—at speeds ranging from one dot every two seconds to one dot every ¼ second, depending on motor rpm. Seventy chart speeds, from ⅛" to 480" per hour, let you select the record-dot density you need by choosing the motor and gear ratio suited to your application.

Other features

1. *Accuracy:* Plus or minus 2%.
2. *Charts:* 2⅛" (5.4 cm) active width with space for an event marker to record in the right margin. Access window exposes chart for writing notations.
3. *OEM Adaptability:* Compact size and low price make it easy to add Minigraph recording ability to other equipment. Hardware furnished with Minigraph for flush mounting. Nameplate snaps out for private labeling, conceals readily accessible zero adjust.
4. *Rugged Case:* Aluminum finished with 3M Nextel blue and charcoal (door) for a suede-like finish resistant to damage.

Probe descriptions		Probes may be ordered separately	
Thermocouple type		**Probe No.***	**Price**
Iron-Constantan for temperature ranges 0-500°F to 0-800°F and 0-300°C to 0-400°C. Type J. Chromel-Alumel for temperature ranges 0-1000°F to 0-2000°F and 0-500°C to 0-1000°C. Type K.		J 69201-1 K 69201-2	$21.00 26.50
Thermistor type GENERAL PURPOSE. Esophageal or rectal temperature in humans and animals. Used with long leads for deep water temperatures. Often buried for sub-soil readings. Used for air where fast response is not required. Most rugged probe. Vinyl tip and lead. Useable to 100°C (212°F). Time constant for A type is 7.0 seconds, and for E type 9.0 seconds.		A 69352-401 E 69352-701	16.00 21.00
ATTACHABLE SURFACE TEMPERATURE. Tape on skin or flat surfaces. Good for heat loss and compression efficiency study of piping systems. Stainless steel cup, epoxy backed. Useable to 100 C (212°F). Time constant either type 1.1 seconds.		D 69352-409 H 69352-709	23.00 31.00
AIR TEMPERATURE. Test rooms, incubators, remote air readings, gas streams, etc. Stainless steel cage around epoxy encapsulated thermistor. Useable to 150 C (300°F). Time constant either type 0.6 seconds.		C 69352-405 G 69352-705	30.00 36.00
TUBULAR. For rugged duty in liquid immersion. Fast response oral or rectal. Stainless steel 3/32" dia. Useable to 150°C (300°F). Time constant either type 3.5 seconds.		B 69352-403 F 69352-703	23.00 31.00

*400 series probes are 2-wire narrow range. 700 series probes are 3-wire wide range.

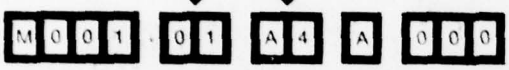
Thermistor Vinyl-covered lead length is 10 ft. (3m).

TEMPERATURE MINIGRAPH RECORDERS

How to Order

It's easy to order the unit you want. Simply specify the range, motor, gear train, probe and option numbers using the tables below.

In the example, M001 indicates 50 to 100 range and scale. 01 designates a 2 rpm chart drive motor rated 120V, 60 Hz. A4 describes the gear train, which provides 1 in./hr. chart speed. A indicates a general purpose thermistor temperature probe. 000 indicates that no options were chosen.



Temperature Range

Range Type	Range Value	Base Price*
M002	−20 to 130°F select probe type E thru H	$205.00
M001	50 to 100°F select probe type A thru D	205.00
M003	80 to 110°F select probe type A thru D	205.00
M016	120 to 240°F select probe E thru H	205.00
M31A	0-500°F includes Type J Probe	158.00
M32A	0-600°F includes Type J Probe	158.00
M33A	0-800°F includes Type J Probe	158.00
M36A	0-1000°F includes Type K Probe	158.00
M37A	0-1200°F includes Type K Probe	158.00
M38A	0-1600°F includes Type K Probe	158.00
M39A	0-2000°F includes Type K Probe	158.00
M009	0-100°C select probe E thru H	205.00
M34A	0-300°C includes Type J Probe	158.00
M35A	0-400°C includes Type J Probe	158.00
M40A	0-500°C includes Type K Probe	158.00
M41A	0-600°C includes Type K Probe	158.00
M42A	0-800°C includes Type K Probe	158.00
M43A	0-1000°C includes Type K Probe	158.00

*Base price includes one range type with chart to match, type 01, 02 or 03 motor and one gear train, portable feet, power cord and flush mounting hardware. F.O.B. shipping point. Shipping wt. approx. 6 lbs.

Charts

Chart Number	Number of Major and Minor Divisions
*69163	U-8-40
*69165	U-12-60
*69176	U-10-50
*69177	U-15-75

*Stock

Six charts per box. Order in multiples of six charts only.
2½" wide, 2¼" active width, 63 feet long.

Quantity	(Box 6 Charts) Price Per Box
1-2 boxes	$13.50
3-5 boxes	12.90
6-15 boxes	12.00
16 or more boxes	11.40

Chart Drive Motor

Drive Type	Description	Add to Base Price
*01	2 RPM 120V, 60Hz, 3 watts	½
02	2 RPM 120V, 50Hz, 3 watts	½
03	2 RPM 240V, 50Hz, 3 watts	½
07	2 RPM 6 VDC, requires 24MA	$ 5.00
06	2 RPM 12 VDC, requires 20MA	35.00
08	2 RPM 28 VDC, requires 10MA	40.00
09	4 RPM 120V, 60Hz, 3 watts	5.00
12	4 RPM 240V, 50Hz, 3 watts	5.00
04	8 RPM 120V, 60Hz, 3 watts	10.00
14	8 RPM 240V, 50Hz, 3 watts	10.00
20	8 RPM 12 VDC, requires 20MA	40.00
05	10 RPM 120V, 60Hz, 3 watts	10.00
15	10 RPM 240V, 50Hz, 3 watts	10.00
19	10 RPM 28 VDC, requires 10MA	40.00
10	16 RPM 120V, 60Hz, 3 watts	10.00
18	16 RPM 240V, 50Hz, 3 watts	10.00
28	16 RPM 28 VDC, requires 10MA	40.00

*Stock

Gear Trains

Gear Train Type	Chart Speed 2 RPM	Inches per Hour** with Various Motors 4 RPM	8 RPM	10 RPM	16 RPM	Record Density Dots Per Inch of Chart
*A1	⅛	¼	½	⅝	1	14,400
*A2	¼	½	1	1¼	2	7,200
*A3	½	1	2	2½	4	3,600
*A4	1	2	4	5	8	1,800
*A5	2	4	8	10	16	900
*A6	3	6	12	15	24	600
*A7	4	8	16	20	32	450
*A8	6	12	24	30	48	300
*A9	10	20	40	50	80	180
*B1	12	24	48	60	96	150
*B2	15	30	60	75	120	120
*B3	30	60	120	150	240	60
*B4	45	90	180	225	360	40
*B5	60	120	240	300	480	30

*Stock

**To determine chart duration in hours, divide 744 by chart speed in inches per hour. This formula is based on 62 usable feet of chart.

Note: Spare gear trains are priced at $5 each.
Price of one gear train is included in base price.

Options

Option Number	Description	Add to Base Price
*000	No Options	None
001	Event Marker 6V DC	$21.00
002	Event Marker 12V DC	21.00
003	Event Marker 24V DC	21.00
004	Event Marker 120V, 50-60Hz	31.50
005	Event Marker 240V, 50-60Hz	31.50

*Stock

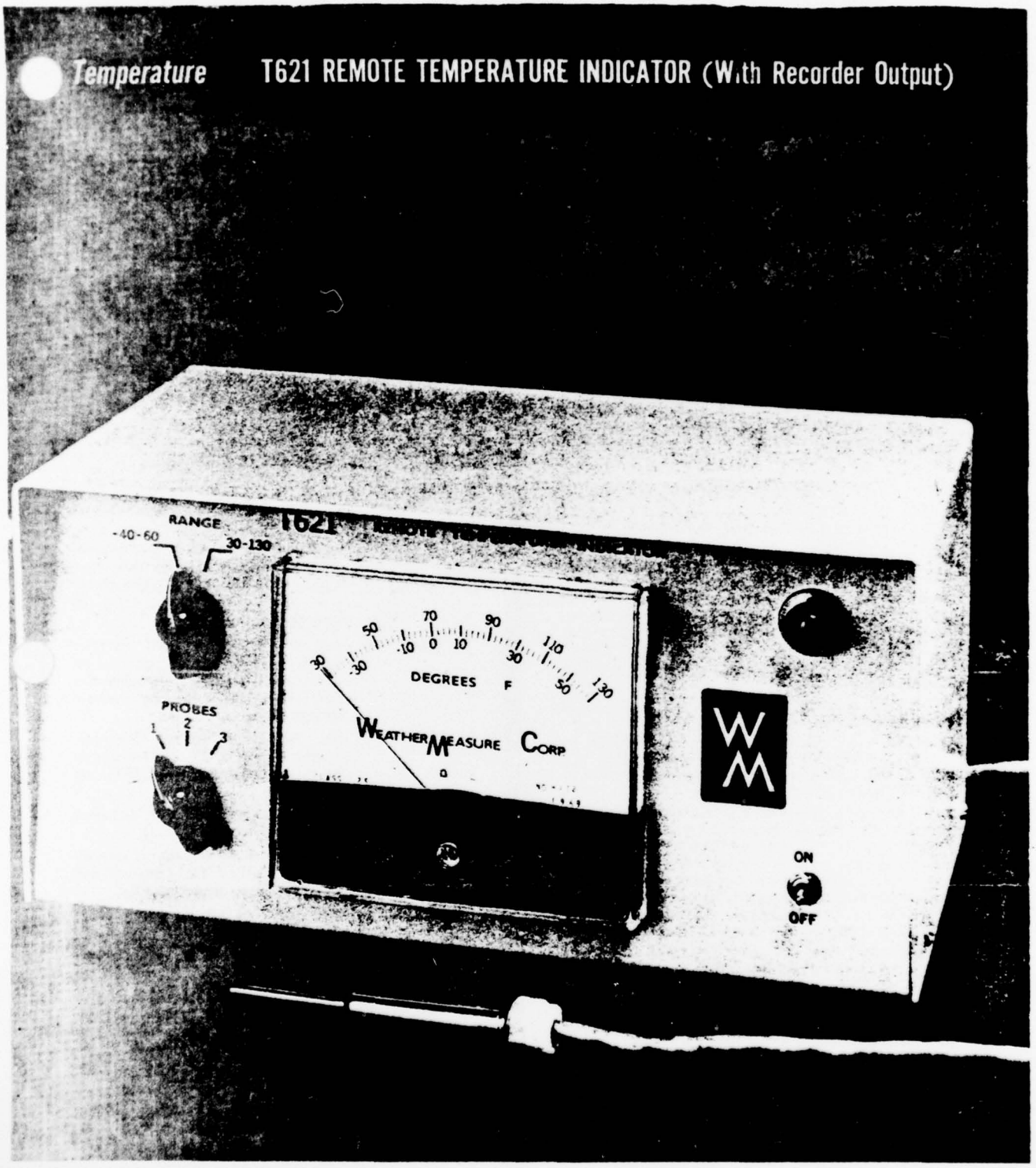
Probes

Probe Type	Description	Add to Base Price
Thermocouple —	The dash instead of letter means probe included in base price. Applies to J and K probe only.	None
Thermistor		
A	Gen. Purpose	$16.00
B	Tubular	23.00
C	Air Temp.	30.00
D	Surface Temp.	23.00
E	Gen. Purpose	21.00
F	Tubular	31.00
G	Air Temp.	36.00
H	Surface Temp.	31.00

Esterline Angus
P.O. Box 24000
Indianapolis, Indiana 46224
Tel. (317) 244-7611

Temperature

T621 REMOTE TEMPERATURE INDICATOR (With Recorder Output)



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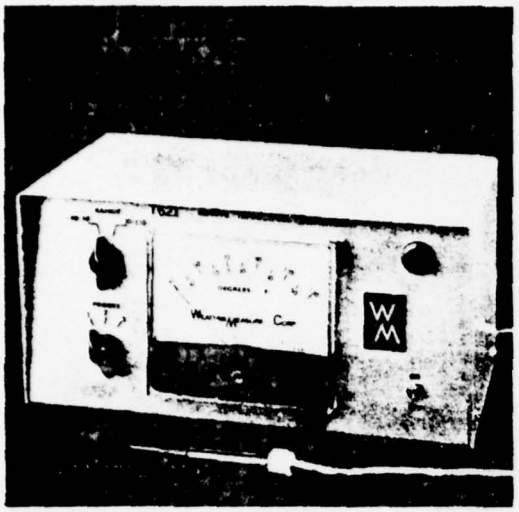

T621 REMOTE TEMPERATURE INDICATOR
(With Recorder Output)

DESCRIPTION

The T621 Remote Temperature Indicator provides a visual indication of temperature as well as an output signal for recording of temperature on a data logger or strip chart recorder. A precision linear thermister is used as the temperature sensor. Temperature is displayed on a 4½" panel meter with an accuracy of ±1°F. The recording output signal is within ±0.3°F. The T621 has two ranges, -40°F to +60°F and 30°F to 130°F. Operation is from 115 V AC or battery power. Up to three temperature probes can be connected to the T621.

Thermister accuracy, linearity, and interchangeability is ±0.27°F over the temperature range from -22°F to 212°F. For special applications linearities as low as ±0.055°C can be provided. The thermistor is sealed with epoxy cement in a stainless steel tube or can be allowed to remain exposed to air if rapid response time is required.

The solid state electronics make use of operational amplifiers to sense changes in thermistor resistance with temperature. The resulting signal is amplified and ranged to operate the panel meter and to provide an output signal suitable for recording on either a galvanometric or potentiometric recorder or a data logger. The output signal can be adjusted to any full scale span in the range from 0 to 1 V DC or 0 to 10 ma.

Temperature sensor and temperature range selection is by means of front panel mounted switches.

For operation on battery power, a 12V DC battery is required.

For maximum reliability the probe and cable should be factory connected and sealed.

APPLICATION

Remote sensing and/or recording of soil, air, and water temperature for meteorological, hydrological, or industrial operations.

SPECIFICATIONS

- Temperature Ranges (Std.) . . . . . -40°F to +60°F and +30°F to 130°F; or -30°C to +20°C and 0-50°C (Custom boards; any 100°F range between -22 and 212°F.)
- Accuracy
  - Panel Meter . . . . . ±1°F
  - *Recorder Signal Output* . . . . . ±0.3°F
- Temperature Sensor . . . . . Linear thermistor, ±0.15°C linearity, std; ±0.055°C optional.
- Sensor Housing . . . . . Stainless steel sheath or exposed bead
- Power . . . . . 115 V AC, 50/60 Hz or +12 DC; 10 ma
- Size . . . . . 12"W x 6½"H x 6¾"D
- Output to Recorder . . . . . 0-1V DC or 0-10 mA standard, others on request
- Weight/Shipping (less cable) . . . . . 4 lbs/10 lbs

ORDERING SPECIFICATIONS

- **T621** — Remote Temperature Indicator, complete with one standard temperature probe in stainless steel tube (specify sealed or exposed bead.) With recorder output signal. 115 VAC, 50/60 Hz. Specify °F or °C.
- **T621-DC** — Remote Temperature Indicator, same as above except operates on 12V DC or 115 VAC, 50/60 Hz.
- **T621-BD105-1** — Ambient Temperature Circuit Board for custom systems, including calibration resistors for 0 and full scale calibration points, mating 22 pin connector, premium range resistors.
- **T621-T18** — Air Temperature Standard Thermistor Probe, ¼" o.d. x 3" L stainless steel jacket, interchangeability ±0.15°C, less cable.
- **T621-T018** — Same as above except with perforated stainless steel jacket.
- **T621-TP18X** — Air Temperature Premium Thermistor Probe, ¼" o.d. x 3" L, stainless steel jacket, interchangeability ±0.055°C.
- **T621-TP018X** — Same as above except with perforated stainless steel jacket.
- **T621-TW18** — Water Temperature, standard thermistor probe, ½" o.d. x 3" L, stainless steel jacket, interchangeability ±0.15°C.
- **T621-TWP18X** — Water Temperature, premium thermistor probe, ½" o.d. x 3" L, stainless steel jacket, interchangeability ±0.055°C.
- **T621-C** — 3 conductor cable to connect air temperature probe to indicating console.
- **T621-CW** — 3 conductor neoprene jacketed cable to connect water temperature probe to indicating console.

APPENDIX "C"

Excerpts from Public Law 95-101:

Military Construction Authorization Act 1978

(Printed 12 July 1977)

TITLE I - ARMY

Section 506 Energy Consumption Metering Devices

(a) The Secretary of Defense is authorized to accomplish the installation of energy consumption metering devices on military housing facilities in existence or authorized before the date of enactment of this act at a cost not to exceed -----

(1) For the Department of the Army $16,000,000.

(2) For the Department of the Navy $24,000,000.

and

(3) For the Department of the Air Force $30,000,000.

(b) In addition to all other authorized variations of cost limitations contained in this act and prior military construction authorization acts, the Secretary of Defense may permit increases in such cost limitations by such amounts as may be necessary to install energy consumption metering devices on military family housing facilities as authorized by Subsection (a).

(c) This section shall apply with respect to any military family housing facility in any state, the District of Columbia, the Commonwealth of Puerto Rico, or Guam.

Section 507 Excess Energy Consumption Charges

(a) In order to accomplish energy conservation, the Secretary of Defense shall, under such regulations as he may prescribe -----

(1) Establish a reasonable ceiling for the consumption of energy in any military family housing facility equipped with an appropriate energy consumption metering device; and

(2) Assess the member of the Armed Forces who is the occupant of such facility a charge, at rates to be determined by the Secretary of Defense, for any energy consumption metered at such facility in excess of the ceiling established for such facility pursuant to Paragraph (1).

(b) Any proceeds from excess consumption charges under Subsection (a) shall be deposited in the Department of Defense Family Housing Management Account established by Section 501(a) of the Act entitled "An Act to authorize certain construction at military installations, and for other purposes", approved 27 July 1962 (42 U.S.C. 1594a-1(a)).

(c) This section shall apply with respect to any military family housing facility in any state, the District of Columbia, the Commonwealth of Puerto Rico, or Guam.

(d) The provisions of Subsection (a)(2) shall not be implemented until -----

(1) The Secretary of Defense conducts a test program to determine the feasibility of assessing occupants of military family housing charges for excess energy consumption.

(2) The Secretary of Defense provides the written results of such test program, together with proposed regulations implementing this section, to the Committees on Armed Services and Appropriations of the Senate and the House of Representatives; and

(3) A period of 30 days expires following the date on which the results referred to in Clause (2) have been submitted to such Committees.

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West Point, NY 10996

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